

CHAPTER 21

DROP ZONE COMPUTATIONS AND FORMULAS

Once the composition of the ground party and the selection of a drop zone has been established several technical aspects must be considered and planned for marking the DZ. These technical aspects are critical because of the data that must be used (ground, winds, drift-distance formula, forward throw, release point).

21-1. DROP ZONE FORMULAS FOR GMRS AND VIRS

The procedures for using these formulas are described in this paragraph.

a. **Distance Formula ($D = RT$).** Compute DZ length for a specific mission by using the $D = RT$ formula. (D is the required length of the DZ in meters; R is the ground speed of the aircraft in meters per second; and T is the time required for the aircraft to release its cargo.) To use this formula, some conversions and mathematics are required.

(1) **Airspeed conversion to ground speed.** To find the aircraft ground speed, convert aircraft airspeed (expressed in knots) to ground speed (meters per second). Do this by multiplying knots times .51 (knots x .51) (1 knot equals .51 meter per second). The following table from Chapter 20 is repeated to assist the estimation of aircraft airspeeds.

| TYPE OF AIRCRAFT | DROP SPEED |
|--------------------|---|
| UH-1 | 50 TO 70 KNOTS (OPTIMUM 70 KNOTS) |
| UH-60 | 65 TO 75 KNOTS (OPTIMUM 70 KNOTS) |
| CH-46/53 (USMC) | 80 TO 110 KNOTS (OPTIMUM 90 KNOTS) |
| CH-47 | 80 TO 110 KNOTS (OPTIMUM 90 KNOTS) |
| CH-54 | 65 TO 75 KNOTS (OPTIMUM 70 KNOTS) |
| CH/HH3 (USAF) | 70 TO 90 KNOTS |
| C-5/130/141/KC-130 | 130 TO 135 KNOTS (PERSONNEL) |
| C-5/130/141/KC-130 | 130 TO 150 KNOTS (DOOR BUNDLES, CDS, AND HEAVY EQUIPMENT) (OPTIMUM FOR ALL LOADS 130 KNOTS) |

Table 21-1. Aircraft drop speeds.

(2) **Time over DZ requirement.** To determine the time over the DZ that is needed to release a parachutist or equipment, use the following factors:

(a) Allow 1 second for each parachutist to exit the aircraft; do not include the first parachutist (10 parachutists require 9 seconds). (Mathematically, this is represented as $10 \times 1 - 1$.)

(b) Allow 3 seconds per bundle to exit the aircraft; do *not* include the first bundle (3 bundles would require 6 seconds). (Mathematically, this is represented as $3 \times 3 - 3$.)

(c) Personnel jumping T-10 parachutes may exit both doors simultaneously. The door with the most parachutists is used to calculate the time required.

EXAMPLE: $D = RT$.

What length DZ would 8 jumpers require when jumping from an aircraft flying at a drop speed of 90 knots?

Step 1: Solve for R (answer is expressed in meters per second):
 $\text{airspeed} \times .51$ ($90 \text{ knots} \times .51$) = 45.90 meters per second.

Step 2: Solve for T (answer is expressed in seconds): number of jumpers $\times 1$ - the first jumper ($8 \times 1 - 1$) = 7 seconds.

Step 3: Solve for D (answer is expressed in meters): 45.90 meters per second $\times 7$ seconds = 321.30 meters. Always round up to the nearest whole number. Therefore, $D = 322$ meters, the required DZ length.

b. Time Formula ($T = D/R$). When solved, this formula provides the seconds required to exit the jumpers over the DZ (time = meters divided by meters per second). If a DZ less than the required length must be used, compute the flight time over the DZ to determine how much of the load can be released in one pass. Use the $T = D/R$ formula: T is the time the aircraft is over the DZ in seconds, D is the length of the DZ in meters, and R is the ground speed (rate) of the aircraft in meters per second.

(1) **Airspeed conversion.** Convert the aircraft's airspeed (expressed in knots) to its ground speed (expressed in meters per second) as in the $D = RT$ formula ($\text{knots} \times .51$). Round up the answer to the next whole number.

(2) **Determination of T.** Divide the ground speed conversion number into D (the DZ length); this determines T. Any fractional answer is rounded down to the next whole number.

EXAMPLE: $T = D/R$

How many parachutists from a CH-47 (drop speed of 90 knots) can land on a 750-meter DZ each pass?

T = Number of parachutists.

D = DZ length is 750 meters (given).

R = Airspeed is 46 meters per second ($90 \text{ knots} \times .51 = 45.9$; round up to 46).

Solution: $T = D/R$ ($D \div R$).

$D/R = 750 \text{ meters divided by } 46 \text{ meters per second} = 16.3 \text{ seconds.}$

$T = 16 \text{ seconds (round down).}$

16 seconds over DZ $\times 1$ parachutist per second + 1 parachutist (the first parachutist exiting the aircraft does not affect the number of seconds spent over the DZ) = 17 parachutists. Thus, 17 parachutists can land on the 750-meter-long DZ per pass.

21-2. WIND DRIFT

Two means of determining wind drift are the WSVC method and the $D = KAV$ formula.

a. **Wind Streamer Vector Count.** The WSVC method (Figure 21-1, page 21-4) is used when the release point is determined from the air. It is normally jumpmaster-executed and does not require markings to be placed on the DZ.

(1) **Streamer drop.** On the first aircraft pass over the desired point of impact, a streamer is dropped from the aircraft. The aircraft then turns to allow the JM to keep the streamer in sight. The pilot adjusts his route so that the flight path is over the streamer on the ground and the desired impact point (in a straight line).

(2) **Count.** As the aircraft passes over the streamer, the JM begins a count, stopping the count directly over the impact point. He immediately begins a new count. When that count equals the first count, the aircraft is over the release point for the first parachutist.

(3) **Aircraft flight adjustment.** The pilot then maneuvers the aircraft to fly along the axis of the DZ and over the release point. Slight adjustments may be made by observing the parachutists as they land on the DZ.

NOTE: This method should not be used for tactical employment, since the aircraft is required to make multiple passes over the DZ.

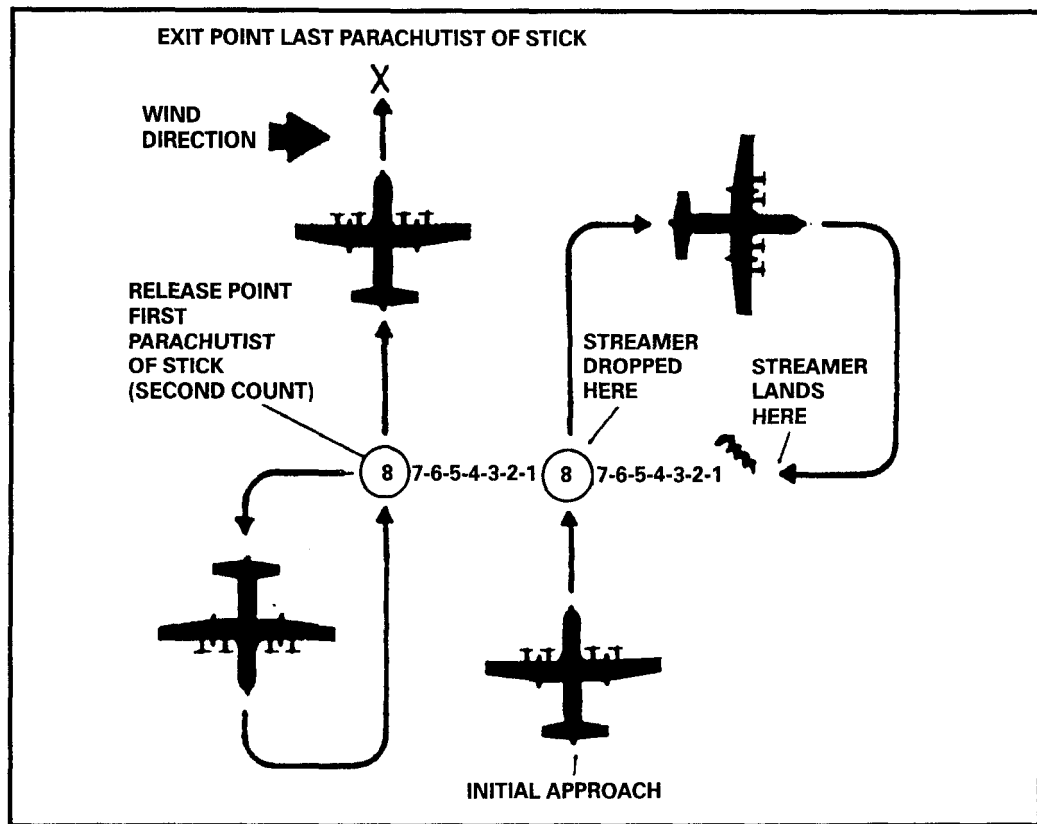


Figure 21-1. Determination of the release point by WSVC.

b. **D = KAV Formula.** This is another method for determining the effects of wind on a parachute.

D = Drill of parachute (in meters) from a given altitude.

K = Constant that represents the typical drift characteristic for a type of parachute. Those constants are—

- 1.5 for cargo parachutes and heavy equipment (HD or HE).
- 3.0 for personnel parachutes.
- 2.4 for tactical training bundles.

A = Drop altitude (expressed in hundreds of feet AGL).

V = Wind velocity in knots (obtained from the mean effective wind [MEW] measurement using the PIBAL, or surface wind velocity measured with an authorized anemometer).

NOTE: If aircraft must be shut down for a long period, a wind drift indicator should be thrown at the last release point to ensure the release point is still valid.

21-3. WIND VELOCITY

Two options are available for determining wind velocity.

a. **Mean Effective Wind.** The most effective option is the use of MEW. This reading is a constant wind speed average from drop altitude to the ground. The PIBAL system determines the MEW. This system should be used when possible; it is more reliable than the other option, which measures surface wind velocity only.

b. **Surface Wind Measurement.** Either the AN/PMQ-3A or commercial anemometers authorized by USAIS messages DTG 101000Z MAR 94, subject: Use of Anemometers During Airdrop Operations, and DTG 212000Z OCT 94, subject: Use of Turbometer During Static Line Airdrop Operations, are recommended for use. Other anemometers not recommended for use should be employed only after a command-initiated risk assessment is completed. Regardless of the method or device used to measure DZ winds, the airborne commander is responsible for ensuring winds on the DZ do not exceed 13 knots during static line personnel airdrops.

EXAMPLE: $D = KAV$

An aircraft is dropping cargo from 500 feet AGL with a surface wind of 10 knots. What is the calculated parachute drift? (The parachute drift is calculated using the $D = KAV$ formula.)

D = Wind-induced drift in meters.

K = Wind drift constant for type of parachute,

A = Drop altitude expressed in hundreds of feet (500 feet would be expressed as 5).

V = Velocity of wind in knots (either MEW or surface wind measurement).

Step 1: $K = 1.5$ (cargo parachute or HE constant).

Step 2: $A = 5$ (500 feet).

Step 3: $V = 10$ (10 knots).

Step 4: $D = 1.5 \times 5 \times 10 = 75.0$, or 75 meters of drift. (Any fractional answer is rounded up to the nearest whole number.)

c. **Equipment.** The equipment needed to compute the MEW by the PIBAL method is as follows:

- Helium source.
- Pilot balloons (10 or 30 grams).

- Drift scale or other device for measuring from 0 to 90 degrees.
- Balloon measuring tape (to measure balloon circumference) (10 gram—57 inches day, 74 inches night; 30 gram—78 inches day, 94 inches night).
- PIBAL lighting units (Type 5) for night use (liquid-activated lights).
- Compass.
- Conversion charts (10 and 30 gram) (Tables 21-2 and 21-3).
- Watch with second hand.

d. **Procedure.** The procedure for measuring MEW using the PIBAL is as follows:

- (1) Fill the 10-gram or 30-gram balloon with helium to the required size.
- (2) Check the conversion chart for drift time to drop altitude (Tables 21-2 and 21-3).
- (3) Release the balloon and begin timing.
- (4) Keep the balloon in sight.
- (5) Once the required time has elapsed, determine the azimuth to the balloon with the compass and read the degrees from the drift scale.
- (6) Refer to the conversion chart and read down the angle column to the number closest to the angle on the scale.
- (7) Read across the top of the chart (altitude in feet) to the drop altitude in use. Read down this column until the two lines (6 and 7) intersect.
- (8) Where the two lines intersect is the MEW at drop altitude, in knots. The direction of the MEW is the back azimuth of the compass reading that was taken at the same time as the angle measurement.
- (9) The MEW becomes the variable V in the $D = KAV$ formula to determine the amount of drift in meters.

NOTE: A parachute's K-factor is based on the parachute's flight characteristics, not on its mode of use. IAW Chapter 2, FM 10-500-3/TO 13C7-1-11, *Rigging Containers*, Dec 92, the K-factor for the T-10 parachute used in the cargo mode is the same (3.0) as for personnel drops using the T-10 parachute.

| 10-GRAM HELIUM BALLOON | | | | | | | | | | | | | |
|--|---------------------|----|----|----|----|----|----|----|----|----|----|----|--------------------|
| INFLATE BALLOON TO 57" CIRCUMFERENCE FOR DAY AND 74" CIRCUMFERENCE FOR NIGHT | | | | | | | | | | | | | |
| DROP ALTITUDE IN FEET | | | | | | | | | | | | | |
| 500 750 1000 1250 1500 1750 2000 2500 3000 3500 4000 4500 | | | | | | | | | | | | | |
| ELEVATION ANGLE | 70 | 02 | 02 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | ASCENSION TABLE |
| | 60 | 03 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | |
| | 55 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | TIME |
| | 50 | 04 | 04 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | 03 | ALT (FT) |
| | 45 | 05 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 0:10 80 |
| | 40 | 06 | 05 | 05 | 05 | 05 | 05 | 04 | 04 | 04 | 04 | 04 | 0:20 170 |
| | 35 | 07 | 06 | 06 | 06 | 05 | 05 | 05 | 05 | 05 | 05 | 05 | 0:30 250 |
| | 30 | 08 | 07 | 07 | 07 | 07 | 07 | 07 | 06 | 06 | 06 | 06 | 0:40 330 |
| | 25 | 10 | 09 | 09 | 09 | 08 | 08 | 08 | 08 | 08 | 08 | 08 | 0:50 400 |
| | 24 | 11 | 10 | 09 | 09 | 09 | 09 | 08 | 08 | 08 | 08 | 08 | 1:02 500 |
| | 23 | 11 | 10 | 10 | 09 | 09 | 09 | 09 | 08 | 08 | 08 | 08 | 1:10 540 |
| | 22 | 12 | 11 | 10 | 10 | 10 | 10 | 09 | 09 | 09 | 09 | 09 | 1:20 610 |
| | 21 | 12 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 1:30 670 |
| | 20 | 13 | 12 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 1:43 750 |
| | 19 | 14 | 13 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 1:50 790 |
| | 18 | 15 | 13 | 13 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 2:25 1000 |
| | 17 | 16 | 14 | 13 | 13 | 13 | 13 | 12 | 12 | 12 | 12 | 12 | 2:44 1100 |
| | 16 | 17 | 15 | 14 | 14 | 14 | 13 | 13 | 13 | 13 | 13 | 13 | 3:05 1250 |
| | 15 | 18 | 16 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 3:49 1500 |
| | 14 | 19 | 17 | 16 | 16 | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 4:30 1750 |
| | 13 | 21 | 19 | 18 | 17 | 17 | 17 | 17 | 16 | 16 | 16 | 16 | 5:11 2000 |
| | 12 | 22 | 20 | 19 | 19 | 18 | 18 | 18 | 18 | 17 | 17 | 17 | 6:34 2500 |
| | 11 | 24 | 22 | 21 | 21 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 7:58 3000 |
| | 10 | 27 | 25 | 23 | 23 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 9:22 3500 |
| | 09 | 30 | 27 | 26 | 26 | 25 | 24 | 24 | 24 | 23 | 23 | 23 | 10:44 4000 |
| | | | | | | | | | | | | | 12:08 4500 |
| | WIND SPEED IN KNOTS | | | | | | | | | | | | |

Table 21-2. The 10-gram PIBAL chart.

| 30-GRAM HELIUM BALLOON INFLATE BALLOON TO 78" CIRCUMFERENCE FOR DAY AND 94" CIRCUMFERENCE FOR NIGHT DROP ALTITUDE IN FEET | | | | | | | | | | | | | | |
|--|-----|-----|------|------|------|------|------|------|------|------|------|------|-----------------|----------|
| ELEVATION ANGLE | 500 | 750 | 1000 | 1250 | 1500 | 1750 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | ASCENSION TABLE | |
| | 80 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | 01 | TIME | ALT (FT) |
| | 70 | 03 | 03 | 03 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | 02 | | |
| | 60 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 04 | 0:10 | 120 |
| | 55 | 05 | 05 | 05 | 05 | 05 | 05 | 05 | 05 | 05 | 05 | 04 | | |
| | 50 | 06 | 06 | 06 | 06 | 06 | 06 | 06 | 06 | 05 | 05 | 05 | 0:20 | 240 |
| | 45 | 07 | 07 | 07 | 07 | 07 | 07 | 07 | 07 | 07 | 06 | 06 | 0:30 | 360 |
| | 40 | 09 | 08 | 08 | 08 | 08 | 08 | 08 | 08 | 08 | 08 | 08 | 0:42 | 500 |
| | 35 | 10 | 10 | 10 | 10 | 10 | 10 | 09 | 09 | 09 | 09 | 09 | 0:50 | 400 |
| | 30 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 1:02 | 600 |
| | 25 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 1:10 | 830 |
| | 24 | 16 | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 1:17 | 1000 |
| | 23 | 17 | 17 | 16 | 16 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 1:46 | 1250 |
| | 22 | 18 | 18 | 17 | 17 | 17 | 17 | 16 | 16 | 16 | 16 | 16 | 2:10 | 1500 |
| | 21 | 19 | 19 | 18 | 18 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 2:34 | 1750 |
| | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 | 18 | 17 | 2:56 | 2000 |
| | 19 | 21 | 20 | 20 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 3:43 | 2500 |
| | 18 | 22 | 22 | 21 | 21 | 21 | 21 | 20 | 20 | 20 | 20 | 20 | 4:31 | 3000 |
| | 17 | 23 | 23 | 23 | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 21 | 5:21 | 3500 |
| | 16 | 25 | 25 | 24 | 24 | 24 | 23 | 23 | 23 | 23 | 22 | 22 | 6:09 | 4000 |
| | 15 | 27 | 27 | 26 | 26 | 25 | 25 | 25 | 25 | 24 | 24 | 24 | 7:00 | 4500 |
| | 14 | 29 | 29 | 28 | 27 | 27 | 27 | 27 | 26 | 26 | 26 | 25 | | |
| | 13 | 31 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 28 | 28 | 27 | | |
| WIND SPEED IN KNOTS | | | | | | | | | | | | | | |

Table 21-3. The 30-gram PIBAL chart.

21-4. FORWARD THROW

Forward throw is the effect that inertia has on a falling object. When an object leaves an aircraft, it is traveling at a speed equal to the speed of the aircraft. The parachutist (or bundle) continues to move in the direction of flight until the dynamics of parachuting takes effect.

a. **Forward Throw for Army Aircraft.** To determine the amount of forward throw for Army aircraft, divide the drop speed of the aircraft in half. This yields the forward throw in meters. (For example, an aircraft flying at 70 knots would have a forward throw of 35 meters.)

b. **Forward Throw for USAF Aircraft.** To determine the forward throw for USAF aircraft, the following distances apply (Table 21-4).

| | C-130 | C-141 | C-5 |
|---|--------------------------|--------------------------|--------------------------|
| PERSONNEL/DOOR BUNDLES | 229 METERS/ 250 YARDS | 229 METERS/ 250 YARDS | 229 METERS/ 250 YARDS |
| HEAVY EQUIPMENT | 458 METERS/ 500 YARDS | 668 METERS/ 730 YARDS | 668 METERS/ 730 YARDS |
| CONTAINER DELIVERY SYSTEM | 503 METERS/ 550 YARDS | 686 METERS/ 750 YARDS | |
| TACTICAL TRAINING BUNDLE | 147 METERS/ 160 YARDS | 147 METERS/ 160 YARDS | |
| NOTE: TO CONVERT YARDS TO METERS, MULTIPLY YARDS BY .9144 TO CONVERT METERS TO YARDS, DIVIDE METERS BY .9144 | | | |

Table 21-4. USAF forward throw data.

21-5. DROP HEADINGS, POINT OF IMPACT, WIND DRIFT COMPENSATION, AND FORWARD THROW COMPENSATION

For CARP operations, the navigator on board the aircraft determines when the load is to be released from the aircraft (when the green light is turned on). For GMRS and VIRS operations, ground personnel determine the release point (Figure 21-2, page 21-10).

a. **Drop Heading.** Drop heading on all DZs depends on two factors—the long axis and prevailing winds. The DZSO or DZSTL uses both when the situation permits. However, the long axis is the primary concern. With a GMRS or CARP DZ, drop heading can be obtained from the MAC Form 339. A circular/random approach DZ does not have a set drop heading. The mission commander notifies the aircrew and the DZ commander of drop heading to be used NLT 24 hours in advance of the airdrop operation.

NOTE: On some DZs, predetermined drop headings must be adhered to.

b. Point of Impact. The location selected where the first bundle or parachutist should land is known as the PI. The PI should be located along the DZ centerline. However, due to the tactical situation, the PI may be located near a woodline. The DZSO or DZSTL uses a buffer zone of 100 meters on one end of the DZ for safety reasons. PI location for GMRS or VIRS is 100 meters in from the leading edge centerline. CARP PI is designated on the MAC Form 339.

c. Wind Drift Compensation. To compensate for wind drift, the DZSO or DZSTL moves from the desired PI into the wind the number of meters calculated using the $D = KAV$ formula. (For example, if drift equals 350 meters from the PI, he faces into the wind and walks 350 meters in a straight line.)

d. Forward Throw Compensation. To compensate for aircraft forward throw, the DZSO or DZSTL faces the back azimuth of the drop heading and walks the appropriate forward-throw distance to the release point.

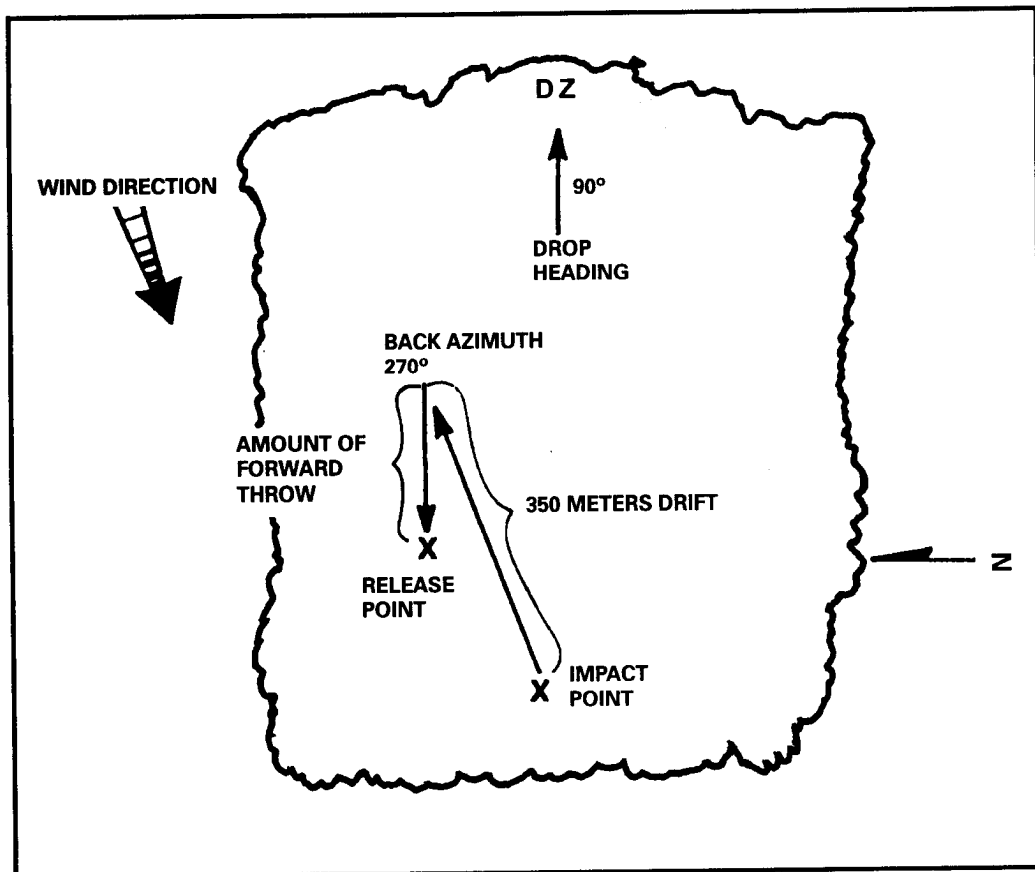


Figure 21-2. RP location for VIRS and GMRS.